APPENDIX B
OVERVIEW OF PRIMARY AND SECONDARY EMISSIONS

The following methods are described in more detail, including references, in the Procedures Document, at epa.gov/ttn/chief/ei_data.html#ETDP.

INTRODUCTION

Emission estimates for particulate matter less than 2.5 microns ($PM_{2.5}$) were developed originally under the National Particulate Inventory Study (NPI). The NPI was a 1990 air emissions inventory for the U.S. (excluding Alaska and Hawaii), Canada and Mexico. In addition to $PM_{2.5}$, the inventory included the following pollutants:

- PM_{10} (particles $\leq$ 10 u
- Sulfur dioxide (SO_2)
- Oxides of nitrogen (NO_x)
- Ammonia (NH_3)
- Volatile organic compounds (VOC)
- Secondary organic aerosols (SOA)

Primary PM emissions may be inventoried as PM_{10} or as $PM_{2.5}$. Emissions of SO_2 and NO_x, assisted by NH_3 that acts as a neutralizing agent, form secondary PM in the atmosphere. The majority of secondary particles are in the $PM_{2.5}$ category. Also, certain VOC species, based on reactivity of the organic compound with atmosphere oxidants, form SOA. Thus, it is necessary to develop a complete inventory of all primarily emitted and secondarily formed PM in order to provide the basis for comprehensive ambient modeling.

For the most part, emissions of SO_2, NO_x, VOC, PM_{10}, $PM_{2.5}$, and NH_3 are based on new methods prepared during the early 1990's. Current estimates are based on VOC, SO_2, and NO_x emissions and/or estimation methodology developed for some source categories from the 1990 Interim Inventory. Also, the current estimates rely on emissions/methods developed for fugitive dust sources in 1996. New or revised emissions/methods were developed for utility, highway, and non-road sources.

The following discussion provides details on both the Trends methods and any new methods developed since 1995.

1. ELECTRIC UTILITY SOURCES

$PM_{2.5}$ and NH_3 emissions for utilities were developed similar to the other pollutants (based on the boiler-level data collected from Form EIA-767). Emission factors for NH_3 were not widely available, and therefore AP-42 factors for uncontrolled emissions were utilized.

The appropriate source classification code (SCC) was assigned to each fuel based on its characteristics. For coal, the SCC is based on the American Society for Testing and Materials (ASTM) criteria for moisture, mineral-free matter basis (if greater than 11,500 Btu/lb, coal type is designated to be bituminous; if between 8,300 and 11,500 Btu/lb, coal type is designated to be subbituminous; and if less than 8,300 Btu/lb, coal type is designated to be lignite) and the boiler type (firing configuration and bottom type) as specified in AP-42. If both coal and oil were burned in the same boiler, it was assumed that the oil is distillate; if only oil was burned, it was assumed to be residual. Then, based on the fuel and boiler type, the SCC is assigned. For natural gas, the SCC is based on fuel and boiler type.

PM_{10} control efficiency was used to calculate both PM_{10} and $PM_{2.5}$ emissions. Since only TSP (Total Suspended Particulate, $\leq \sim 35u$) control efficiency is reported on Form EIA-767, the PM_{10} calculator program was used to derive PM_{10} efficiencies. (The PM-10 calculator estimates PM_{10} control efficiencies based on the SCC and the primary and secondary control devices. The control efficiencies from the PM_{10} calculator are based on data from AP-42 for specific SCCs.) (Refer to the PM Calculator website at epa.gov/ttn/chief/software.html#pm).

The following equation was used to compute controlled PM_{10} and $PM_{2.5}$ emissions:

$$PM_{10} \ or \ PM_{2.5} = \frac{fuel}{burned} \ x \ \frac{AP-42}{emf} \ x \ (1 \ - \ PM_{10} \ or \ PM_{2.5} \ eff) \ x \ \frac{1}{2000} \tag{1}$$

The following equation was used to compute heat input:

$$\frac{heat \ input}{(MMBtu)} = \frac{fuel}{burned} \ x \ \frac{heat}{content} \tag{2}$$

Although Form EIA-767 data are collected from plants with a total plant capacity of at least 10 MW, there are fewer required data elements (identification data, boiler fuel quantity and quality data, and FGD data, if applicable) for those plants with a total capacity between 10 MW and 100 MW. Thus, missing values are introduced in these situations. Because of time constraints, most data elements were not assigned a default value other than zero. If variables for boiler firing and bottom type were missing (these are needed in the SCC assignment) the default values for wall-fired and dry bottom type were assigned. For ambient modeling purposes, it is necessary to know the location (latitude and longitude) of each boiler. If the latitude and

longitude for a specific boiler were missing, they were replaced whenever possible with either (1) the latitude and longitude from other boilers in that same plant or (2) county centroid coordinates.

2. NON-UTILITY POINT SOURCES

The PM_{10}, and $PM_{2.5}$ emissions were calculated using a methodology consistent with emission estimates in the 1990 Interim Inventory/Trends Inventory. This means non-utility point source emissions are calculated based on emission estimates from the 1985 NAPAP Inventory projected to 1990 using Bureau of Economic Analysis (BEA) Industrial Earnings data. Because annual PM_{10} and $PM_{2.5}$ emission estimates are not available from the NAPAP files, annual TSP emissions were used as the starting point for estimating PM_{10} and $PM_{2.5}$ emissions. The procedure used to estimate 1990 PM_{10}, $PM_{2.5}$ and NH_3 emissions from the 1985 NAPAP TSP emissions is described below.

1) projected 1985 controlled TSP emissions to 1990 using appropriate BEA growth factors; 2) calculated 1990 uncontrolled TSP emissions from controlled emissions and the control efficiency from the 1985 NAPAP inventory; 3) 1990 uncontrolled PM_{10} emissions were estimated by applying SCC-specific uncontrolled particle-size distribution factors to the uncontrolled TSP emissions; 4) controlled PM_{10} emissions were estimated using revised control efficiencies from the PM_{10} calculator.

For $PM_{2.5}$, 1990 uncontrolled $PM_{2.5}$ emissions were estimated by applying SCC-specific uncontrolled particle-size distribution factors to the 1990 uncontrolled PM_{10} emissions. As with PM_{10}, controlled $PM_{2.5}$ emissions were estimated using revised control efficiencies from the PM_{10} calculator.

Calculation of NH_3 Emissions. Ammonia emissions were calculated by growing the 1985 NAPAP emissions using the BEA growth factors, and the following formula:

$$CNH_{3(90)} = (CNH_{3(85)} \ x \ EG_{85-90}) \qquad\qquad (3)$$

Where:
> $CNH_{3(90)}$ = Controlled NH_3 Emissions for 1990
> $CNH_{3(85)}$ = Controlled NH_3 Emissions for 1985 NAPAP
> EG_{85-90} = Earnings growth from 1985 to 1990

3. AREA SOURCES:

3.a. **Fertilizer applications**: NH_3 emissions created from the application of fertilizers were updated for the period 1991-1997, and summary tables are published in Appendix A of this update. New data on fertilizer usage were obtained from the Association of American Plant Food

Control Officials, Inc. and the Fertilizer Institute. These groups jointly produce the Commercial Fertilizers data base. Actual data from the Association was used for 1990 and 1996; the intervening years and 1997 were developed using a linear trends analysis based on the Association's data.

3.b. <u>Agricultural Tilling:</u> The following AP-42 particulate emission factor equation was used to determine regional PM_{10} and $PM_{2.5}$ emissions from agricultural tilling:

$$E = c \ x \ k \ x \ s^{0.6} \ x \ p \ x \ a \tag{4}$$

Where:

E	=	PM_{10} emissions (lbs/yr)
c	=	constant 4.8 lbs/acre-pass
k	=	dimensionless particle size multiplier (PM_{10}=0.21, and $PM_{2.5}$= 0.042)
s	=	silt content of surface soil, defined as the mass fraction of particles smaller than 75 μm diameter found in soil to a depth of 10 cm (percent)
p	=	number of passes or tillings in a year (assumed to be 3 passes)
a	=	acres of land planted

By comparing the USDA surface soil map with the USDA county map, soil types were assigned to all counties of the continental U.S. Silt percentages were determined by using a soil texture classification triangle.. Silt factors were updated from previous methods by using information from "Spatial Distribution of PM_{10} emissions from Agricultural Tilling in the San Joaquin Valley." (Refer to Reference 15, Chapter 4, of the Procedures Document). Information in that report indicates that silt contents determined from the classification triangle are typically based on wet sieving techniques. The AP-42 silt content is based on dry sieving techniques. Wet sieving tends to desegregate finer materials thus leading to a higher than expected silt content based on the soil triangle estimates. The overestimation is dependent upon the soil type. As a consequence, the values for silt loam and loam were reduced by a factor of 1.5. The values for clay loam and clay were reduced by a factor of 2.6. The values for sand, loamy sand, sandy loam and organic material remained the same. These silt values were assumed constant for the 6-year period examined. This differs from the 1989 through 1985 methodology in that the silt factors are applied on the county level, and are corrected values.

The number of tillings for 1990 through 1996 were determined for each crop type, and for conservational and conventional use using information from Agricultural Activities Influencing Fine Particulate Matter Emissions. (Refer to Reference 16, Chapter 4, of the Procedures Document). The tillage emission factor ratio column in the tables in that report were totaled by crop type when the agricultural implement code was not blank. Harvesting was not included in this total. When the tilling instrument was felt to deeply disturb the soil, the value of the tillage emission factor ratio was equal to one. However, other field instruments were not felt to disturb the soil to the extent of the instruments used to develop the original AP-42 emission factor and

thus had an emission factor ratio of less than one. Discussions with the organization that developed the original emission factor and the report referenced above indicated that these values should be used to calculate the number of tillings rather than a single value for each implement usage.   Where there were data from more than one region for a single crop, an average value was used. Information for both conservation and conventional tillage methods were developed. The tallies were rounded to the nearest whole number, since it is not physically possible to have a partial tillage event.

These totals were tallied for corn, cotton, rice, sorghum, soybeans, spring wheat, and winter wheat. The number of tillings for categories not included in Agricultural Activities Influencing Fine Particulate Matter Emissions were determined by contact with the Conservation Information Technology Center (CTIC) (Refer to Reference 18, Chapter 4, of the Procedures Document).

Rice and spring wheat are included in the category "spring-seeded small grain" in the database provided by the CTIC. Winter wheat was assumed to prevail in all states except Arkansas, Louisiana, Mississippi, and Texas. Rice was assumed to prevail in these four states, and the number of tillings for rice were applied to the acres harvested in these states. Both rice and winter wheat are grown in California. A ratio of rice to winter wheat acres harvested for 1990 through 1996 was obtained from the U.S. Land Use Summary. This ratio was used to calculate a modified number of tillings for spring-seeded small grain in California for each year.

Acres reported in the CTIC database for no till, mulch till, and ridge till were considered conservation tillage. Those with 0 to 15 percent residue, and 15 to 30 percent residue were considered conventional tillage.

3.c. **Livestock Operations.** The livestock NH_3 emissions in the inventory were estimated using activity data from the 1992 Census of Agriculture. These data included county-level estimates of number of head for the following livestock: cattle and calves, hogs and pigs, poultry, sheep, horses, goats, and minks. The emission factors used to calculate emissions were taken from a study of NH_3 emissions conducted in the Netherlands.

3.d. Construction Activities. The PM_{10} emissions for the years 1985 through 1995, and the $PM_{2.5}$ emission for the years 1990 through 1995 were calculated from an emission factor, an estimate of the acres of land under construction, and the average duration of construction activity. The acres of land under construction were estimated from the dollars spent on construction. The PM_{10} emission factor for the years 1985 through 1989 was calculated from the TSP emission factor for construction obtained from AP-42 and data on the PM_{10}/TSP ratio for various construction activities. The PM_{10} emission factor for the years 1990 through 1995 was obtained from Improvement of Specific Emission Factors. The 1996 emissions were extrapolated from the 1995 emissions using the ratio between the number of residential construction permits issued in 1996 and the number issued in 1995. A control efficiency was applied to emissions for 1995 and

1996 for counties classified as PM nonattainment areas. (For sources of data, please refer to references 31 through 34, Chapter 4, of the Procedures Document).

1990 through 1995 Emission Factor Equation. The equation below is a variation of the AP-42 particulate emission factor equation for heavy construction and was used to determine regional PM_{10} and $PM_{2.5}$ emissions from construction activities for 1990 through 1995. The $PM_{2.5}$ emission factor used for the years 1990 through 1995 was the PM_{10} emission factor multiplied by the particle size adjustment factor of 0.2. A control efficiency was applied to PM nonattainment areas for 1995 and 1996.

$$E = P \times \$ \times f \times m \times \left(1 - \frac{CE}{100} \right) \tag{5}$$

where: E = PM emissions
P = PM emission factor (ton/acre of construction/month of activity)
(PM_{10} = 0.11; $PM_{2.5}$ = 0.022)
\$ = dollars spent on construction (\$ million)
f = factor for converting dollars spent on construction to acres of construction (varies by type of construction, acres/\$ million)
m = months of activity (varies by type of construction)
CE = control efficiency (percent)

Dollars spent on construction (\$). Estimates of the dollars spent on the various types of construction by EPA region for 1987 were obtained from the Census Bureau. The fraction of total U.S. dollars spent in 1987 for each region for each construction type was calculated. Since values from the Census Bureau are only available every five years, the Census dollars spent for the United States for construction were normalized using estimates of the dollars spent on construction for the United States as estimated by the F.W. Dodge corporation for the other years. This normalized Census value was distributed by region and construction type using the above calculated fractions. An example of how this procedure was applied for SIC 1521 (general contractor, residential building: single family) is shown below.

$$\$_{1988,Region I,1521}^{SIC} = \frac{\$_{1987,Nation,Census}}{\$_{1987,Nation,Dodge}} \times \$_{1988,Nation,Dodge} \times \frac{\$_{1987,Region 1,Census,1521}^{SIC}}{\$_{1987,Nation,Census,1521}^{SIC}} \tag{6}$$

where: \$ = dollar amount of construction spent
1988 = year 1988
1987 = year 1987
Region I = U.S. EPA Region I

SIC 1521	=	Standard Industrial Code for general contractor, residential building; single family
Nation	=	United States
Census	=	Census Bureau
Dodge	=	F.W. Dodge

Determination of construction acres. Information developed by Cowherd et al. determined that for different types of construction, the number of acres was proportional to dollars spent on that type construction. The following AP-42 particulate emission factor equation for heavy construction was used to determine regional PM_{10} emissions from construction activities for 1990:

$$E = T \ x \ \$ \ x \ f \ x \ m \ x \ P \qquad\qquad (7)$$

Where:

E	=	PM_{10} emissions tons per year (tpy)
T	=	TSP emission factor (1.2 ton/acre of construction/month of activity)
$	=	dollars spent on construction (million $)
f	=	factor for converting dollars spent on construction to acres of construction (varies by type of construction, acres/million $)
m	=	months of activity per year (varies by type of construction)
P	=	dimensionless PM_{10}/TSP ratio (0.22)

Estimates of the dollars spent on the various types of construction by EPA region for 1987 were obtained from the Census Bureau. The fraction of total U.S. dollars spent in 1987 for each region for each construction type was calculated. Since values from the Census Bureau are only available every five years, the Census dollars spent in the U.S. for construction were normalized for 1990 using estimates of the dollars spent on construction in the U.S. as estimated by the F.W. Dodge corporation. This normalized Census value was distributed by region and construction type using the above calculated fractions.

EPA determined that for different types of construction, the number of acres was proportional to dollars spent on that type construction. This information (proportioned to constant dollars) was utilized along with total construction receipts to determine the total number of acres of each construction type. Estimates of the duration (in months) for each type construction were derived from EPA PM_{10}/TSP ratios for 19 test sites for 3 different construction activities were averaged to derive the PM_{10} fraction used in the emission estimates.

Regional-level PM_{10} estimates were distributed to the county-level using county estimates of payroll for construction (SICs 15, 16, 17) from County Business Patterns (BOC, 1992). The following formula was used:

$PM_{2.5}$ emissions were then calculated using the county-level PM_{10} emissions by applying the particle size ratio of 0.2.

$$County\ Emissions\ =\ \frac{County\ Construction\ Payroll}{Regional\ Construction\ Payroll}\ x\ Regional\ Emissions \qquad (8)$$

3.e. <u>Unpaved Roads</u>: Estimates of PM emissions from reentrained road dust on unpaved roads were developed for each county. The OMS PART5 model was utilized to obtain the emission factors (refer to Section 4.c. On-Road Vehicles, later in this update). Reentrained road dust emission factors depend on the average weight, speed, and number of wheels of the vehicles traveling on the unpaved roadways, the silt content of the roadway surface material, and the percentage of days in the year with minimal (less than 0.01 inches) or no precipitation. Emissions were calculated by month at the state/road type level for the average vehicle fleet and then allocated to the county/road type level by land area. The activity factor for calculating reentrained road dust emissions on unpaved roads is the VMT accumulated on these roads. The specifics of the emission estimates for reentrained road dust from unpaved roads are discussed in more detail below.

The following equation was used in PART5 to calculate PM emission factors from reentrained road dust on unpaved roads, is based on an empirical formula from AP-42.

$$UNPVD\ =\ PSUNP_{PS}\ x\ 5.9\ x\ (SILT/12)\ x\ (SPD/30)\ x\ (WEIGHT/3)^{0.7}\ x\ (WHEELS/4)^{0.5}\ x$$
$$(365-IPDAYS)/365\ x\ 453.392 \qquad (9)$$

where:
UNPVD	=	unpaved road dust emission factor for all vehicle classes combined (grams per mile)
$PSUNP_{PS}$	=	fraction of particles less than 10 or 2.5 microns from unpaved road dust (0.36 for PM_{10} and 0.05 for $PM_{2.5}$)
SILT	=	percentage silt content of the surface material
SPD	=	average speed of all vehicle types combined (miles per hour [mph])
WEIGHT	=	average weight of all vehicle types combined (tons)
WHEELS	=	average number of wheels per vehicle for all vehicle types combined
IPDAYS	=	number of precipitation days per year with greater than 0.01 inches of rain
493.592	=	number of grams per pound

The above equation is based on roadside measurements of ambient particulate matter, and is therefore representative of a fleet average emission factor rather than a vehicle-specific emission factor. In addition, because this equation is based on ambient measurements, it includes particulate matter from tailpipe exhaust, brake wear, tire wear, and ambient background particulate concentrations. Therefore, the PART5 fleet average PM emission factors for the

tailpipe, tire wear, and brake wear components were subtracted from the unpaved road fugitive dust emission factors before calculating emissions from Reentrained road dust on unpaved roads.

Silt Content Inputs: Average state-level, unpaved road silt content values developed as part of the 1985 NAPAP Inventory, were obtained from the Illinois State Water Survey. Silt contents of over 200 unpaved roads from over 30 states were obtained. Average silt contents of unpaved roads were calculated for each state that had three or more samples for that state. For states that did not have three or more samples, the average for all samples from all states was substituted.

Precipitation Inputs. Rain data input to the emission factor equation above is in the form of the total number of rain days in the year. However, the equation uses the number of days simply to calculate a percentage of rain days. Therefore, to calculate unpaved road dust emission factors that represent monthly conditions, data from the National Climatic Data Center showing the number of days per month with more than 0.01 inches of rain were used. Precipitation event accumulation data were collected for several meteorological stations within each state.

Vehicle Wheel, Weight, and Speed Inputs: The speeds for light duty vehicles and trucks were also assumed to be the average unpaved road speeds for the corresponding unpaved road classification. However, because the fugitive dust emission factors are representative of the entire vehicle fleet, these speeds for each road type were weighted by vehicle-specific VMT to obtain road type-specific speeds. Estimates of average vehicle weight and average number of wheels per vehicle over the entire vehicle fleet were based on data provided in the *Truck Inventory and Use Survey*, *MVMA Motor Vehicle Facts and Figures '91*, and the *1991 Market Data Book*.   Using these data sources, a fleet average vehicle weight of 6,358 pounds was modeled.

Unpaved road VMT.   The calculation of unpaved road VMT was performed in two parts. Separate calculations were performed for county and noncounty (state or federally) maintained roadways. The 1995 unpaved VMT was also used for 1996, as unpaved growth is very uncertain, but expected to be minimum. The equation used is:

$$VMTUP \ = \ ADTV \ x \ FSRM \ x \ DPY \qquad\qquad (10)$$

where: VMTUP   =   VMT on unpaved roads (miles/year)
        ADTV   =   average daily traffic volume (vehicles/day/mile)
        FSRM   =   functional system roadway mileage (miles)
        DPY   =   number of days in a year

Estimation of Local Unpaved-Road VMT. Unpaved roadway mileage estimates were retrieved from the FHWA's annual *Highway Statistics* report. State-level, county-maintained roadway mileage estimates are organized by surface type, traffic volume, and population category. From these data, state-level unpaved roadway mileage estimates are derived. This was done by first assigning an average daily traffic volume (ADTV) to each volume category.

The above equation was then used to calculate state-level unpaved road VMT estimates for volume and population categories. These detailed VMT data were then summed to develop state-level, county-maintained unpaved roadway VMT.

Estimation of Federal and State-Maintained Unpaved Road VMT: The calculation of noncounty (state or federally) maintained unpaved road VMT differed from the calculation of county-maintained unpaved road VMT. This was required since noncounty unpaved road mileage was categorized by arterial classification, not roadway traffic volume.

To calculate noncounty, unpaved road VMT, state-level ADTV values for urban and rural roads were multiplied by state-level, rural and urban roadway mileage estimates. Assuming the ADTV does not vary by roadway maintenance responsibility, the county-maintained ADTV values were assumed to apply to noncounty-maintained roadways as well. To develop noncounty unpaved road ADTV estimates, county-maintained roadway VMT was divided by county-maintained roadway mileage estimates.

$$ADTV \ = \ VMT \ / \ MILEAGE \tag{11}$$

where: ADTV   =   average daily traffic volume for state and federally maintained roadways
       VMT   =   VMT on county-maintained roadways (miles/year)
       MILEAGE   =   state-level roadway mileage of county-maintained roadways (miles)

Federal and state-maintained roadway VMT was calculated by multiplying the state-level roadway mileage of federal and state-maintained unpaved roads by the state-level ADTV values calculated as discussed above for locally-maintained roadways, as follows:

$$VMT \ = \ ADTV \ x \ RM \ x \ 365 \tag{12}$$

where: VMT   =   VMT at the state level for federally and state-maintained unpaved roadways (miles/year)
       ADTV   =   average daily traffic volume derived from local roadway data
       RM   =   state-level federally and state-maintained roadway mileage (mi)

Unpaved-Road VMT For 1993 and Later Years: The calculation of unpaved VMT differs for years before 1993 and for the year 1993 and later years. This split in methodology is due a difference in the data reported by states in the annual Highway Statistics. In both instances the calculation was performed in two stages.

Unpaved VMT for 1993 and later years was calculated by multiplying the total number of miles of unpaved road by state and functional class by the annualized traffic volume, where the

annualized traffic volume is calculated as the average daily traffic volume multiplied by the total number of days per year. This calculation is illustrated as follows:

$$UnpavedVMT_{Roadtype} = Mileage_{Roadtype} \ x \ ADTV \ x \ DPY \qquad (13)$$

where: Unpaved VMT = road type specific unpaved Vehicle Miles Traveled (miles/year)

Mileage = total number of miles of unpaved roads by functional class (miles)

ADTV = Average daily traffic volume (vehicle/day)

DPY = number of days per year

The total number of unpaved road miles by state and functional class was retrieved from the Federal Highway Administration's Highway Statistics. In Highway Statistics, state level Local functional class unpaved mileage is broken out by ADTV category. The ADTV categories differed for urban and rural areas. Table MV-1 of Highway Statistics shows the ADTV categories for rural and urban local functional classes and the assumed traffic volume for each category. Local functional class unpaved VMT was calculated for each of these ADTV categories using the equation illustrated above.

Unpaved road mileage for functional classes other than Local (rural minor collector, rural major collector, rural minor arterial, rural other principal arterial, urban collector, urban minor arterial, urban other principal arterial) are not broken out by ADTV in Highway Statistics. An average ADTV was calculated for these functional classes by dividing state level unpaved Local VMT by the total number of miles of Local unpaved road. Separate calculations were preformed for urban and rural areas. The resulting state level urban and rural ADTV was then multiplied by the total number of unpaved miles in each of the non-local functional classes.

One modification was made to the Local functional class mileage reported in Highway Statistics. The distribution of mileage between the ADTV categories for Mississippi resulted in unrealistic emissions. Total unpaved road mileage in Mississippi was redistributed within the ADTV categories based on the average distributions found in Alabama, Georgia, and Louisiana.

Calculation of State-Level Emissions. The state and federally maintained unpaved road VMT were added to the county- maintained VMT for each state and road type to determine each state's total unpaved road VMT by road type. The state-level unpaved road VMT by road type were then temporally allocated by month using the same NAPAP temporal allocation factors used to allocate total VMT. These monthly state-level, road type-specific VMT were then multiplied by the corresponding monthly, state-level, road type-specific emission factors developed as discussed above. These state-level emission values were then allocated to the county level using the procedure discussed below.

B-11

Allocation of State-Level Emissions to Counties. The state/road type-level unpaved road PM emission estimates were then allocated to each county in the state using estimates of county rural and urban land area from the U.S. Census Bureau for the years 1985 through 1989.

$$PM_{X,Y} = (CNTYLAND_{URB,X}/STATLAND_{URB}) \ x \ PM_{ST,URB,Y}$$
$$+ (CNTYLAND_{RUR,X}/STATLAND_{RUR}) \ x \ PM_{ST,RUR,Y}$$

$$(14)$$

where: $Pm_{x,y}$ = unpaved road PM emissions (tons) for county x and road type y

$CNTYLAND_{URB,X}$ = urban land area in county x

$STATLAND_{URB}$ = urban land area in entire state

$PM_{ST,URB,Y}$ = unpaved road PM emissions in entire state for urban road type y

$CNTYLAND_{RUR,X}$ = rural land area in county x

$STATLAND_{RUR}$ = rural land area in entire state

$PM_{ST,RUR,Y}$ = unpaved road PM emissions in entire state for rural road type y

For the years 1990 through 1996, 1990 county-level rural and urban population was used to distribution the state-level emissions instead of land area.

Nonattainment Area 1995 and 1996 Unpaved-Road Controls. PM control measures were applied to the unpaved road emission estimates for the years 1995 and 1996 and for the projection years. The level of control assumed varied by PM nonattainment area classification and by rural and urban areas. On urban unpaved roads in moderate PM nonattainment areas, the assumed control was paving the unpaved roads. This control was applied with a 96 percent control efficiency and a 50 percent penetration rate. On rural roads in serious PM nonattainment areas, chemical stabilization was the assumed control. This control was applied with a 75 percent control efficiency and a 50 percent penetration rate. On urban unpaved roads in serious PM nonattainment areas, paving and chemical stabilization were the controls assumed to be applied. This combination of controls was applied with an overall control efficiency of 90 percent and a penetration rate of 75 percent.

3.f. Paved Roads*:* Estimates of PM emissions from reentrained road dust on paved roads were developed at the county level in a manner similar to that for unpaved roads. PART5 reentrained road dust emission factors for paved roads depend on the road surface silt loading and the average weight of all of the vehicles traveling on the paved roadways. The equation used in PART5 to calculate PM emission factors from reentrained road dust on paved roads is a generic paved road dust calculation formula from AP-42.

$$PAVED = PSDPVD \; x \; (PVSILT/2)^{0.65} \; x \; (WEIGHT/3)^{1.5} \qquad\qquad (15)$$

where: PAVED   =   paved road dust emission factor for all vehicle classes combined (grams per mile)

PSDPVD   =   base emission factor for particles of less than 10 or 2.5 microns in diameter from paved road dust (7.3 g/mi for PM_{10} and 1.825 g/mi for $PM_{2.5}$)

PVSILT   =   road surface silt loading (g/m^2)

WEIGHT   =   average weight of all vehicle types combined (tons)

Paved road silt loadings were assigned to each of the twelve functional roadway classifications (six urban and six rural) based on the average annual traffic volume of each functional system by state. One of three values was assigned to each of these road classes, 1 (gm/m^2) was assigned Local functional class roads, and either 0.20 (gm/m^2) or 0.04 (gm/m^2) was assigned to each of the other functional class roads. A silt loading of 0.20 (gm/m^2) was assigned to a road types that had an ADTV less than 5000 and 0.04 (gm/m^2) was assigned to road types that had an ADTV greater than or equal to 5000. ADTV was calculated by dividing annual VMT by state and functional class by state specific functional class roadway mileage.

As with the PART5 emission factor equation for unpaved roads, the above PM emission factor equation for paved roads is representative of a fleet average emission factor rather than a vehicle-specific emission factor and it includes particulate matter from tailpipe exhaust, brake wear, tire wear, and ambient background particulate concentrations. Therefore, the PART5 fleet average PM emission factors for the tailpipe, tire wear, and brake wear components were subtracted from the paved road fugitive dust emission factors before calculating emissions from reentrained road dust on paved roads.

The emission factors obtained from PART5 were modified to account for the number of days with a sufficient amount of precipitation to prevent road dust resuspension. The PART5 emission factors were multiplied by the fraction of days in a month with less than 0.01 inches of precipitation. This was done by subtracting data from the National Climatic Data Center showing the number of days per month with more than 0.01 inches of precipitation from the number of days in each month and dividing by the total number of days in the month. These emission factors were developed by month at the state and road type level for the average vehicle fleet.

For the years 1990 to 1996 the rain correction factor applied to the paved road fugitive dust emission factors was reduced by 50 percent.

VMT from paved roads was calculated at the state/road type level by subtracting the state/road type-level unpaved road VMT from total state/road type-level VMT. Because there are differences in methodology between the calculation of total and unpaved VMT there are instances where unpaved VMT is higher than total VMT. For these instances, unpaved VMT was

reduced to total VMT and paved road VMT was assigned a value of zero. The paved road VMT were then temporally allocated by month using the NAPAP temporal allocation factors for VMT. These monthly/state/road type-level VMT were then multiplied by the corresponding paved road emission factors developed at the same level.

These paved road emissions were allocated to the county level according to the fraction of total VMT in each county for the specific road type. The following equation illustrates this allocation.

$$PVDEMIS_{X,Y} = PVDEMIS_{ST,Y} \; x \; VMT_{X,Y}/VMT_{ST,Y} \qquad (16)$$

where: $PVDEMIS_{X,Y}$ = paved road PM emissions (tons) for county x and road type y
$PVDEMIS_{ST,Y}$ = paved road PM emissions (tons) for the entire state for road type y
$VMT_{X,Y}$ = total VMT (million miles) in county x and road type y
$VMT_{ST,Y}$ = total VMT (million miles) in entire state for road type y

PM control measures were applied to the paved road emission estimates for the years 1995 and 1996. The control assumed was vacuum sweeping on paved roads twice per month to achieve an control level of 79 percent. This control was applied to urban and rural roads in serious PM nonattainment areas and to urban roads in moderate PM nonattainment areas. The penetration factor used varied by road type and NAA classification (serious or moderate).

3.g. Wind Erosion: PM_{10} wind erosion emission estimates for agricultural lands were calculated using a modification of the methodology used by Gillette and Passi to develop wind erosion emission estimates for the 1985 NAPAP Inventory. Several simplifying assumptions were made in order to perform the calculations using a spreadsheet model. The NAPAP methodology and the method used to develop the wind erosion estimates in this study both determine expected dust flux based on the probability distribution of wind energy. The methodology uses the mean wind speed coupled with information concerning the threshold friction velocity for the soil and information on precipitation to predict the wind erosion flux potential for soils.

The basic equation used to determine the expected dust flux is given by the following equation:

$$I = k \; x \; C \; x \; C_d \; x \left(\frac{u}{0.886} \right)^4 x \; \Gamma(3,x) \qquad (17)$$

Where:
I = dust flux (gm/cm^2/sec)
k = PM_{10} particle size multiplier (0.9)

B-14

C = constant (4×10^{-14} gm/cm^2/sec)
C_d = coefficient of drag
u = mean wind speed (cm/sec)
$\Gamma(3,x)$ = incomplete gamma function (i.e., probability distribution)

In order to evaluate (3,x), x must be determined from the following equation:

$$x = \left(u_t \; x \; \frac{0.886}{u} \right)^2 \qquad (18)$$

The threshold velocity (u_t) can be determined from the threshold friction velocity (u_{*t}, which is a function of soil type and precipitation) from the following equation:

$$u_t = \frac{u_{x\,t}}{C_d^{\,0.5}} \qquad (19)$$

In order to calculate the flux of emissions from wind erosion using the above equation, information concerning the average monthly wind speed, total monthly precipitation, and anemometer height used to measure the wind speed was necessary. Values for monthly wind speed, total monthly precipitation, and anemometer height were obtained from the local climatological data for several meteorological stations within each State. For most States, several meteorological stations' data were obtained and an overall average was determined for the State. The anemometer height was used to determine the coefficient of drag (C_d) from the following equation:

$$C_d = \left(\frac{0.23}{\ln z_a} \right)^2 \qquad (20)$$

Where:
z_a = anemometer height

Information concerning the average soil type for each State was determined from the USDA surface soil map. A single soil type was assigned to each State in order to determine a single value for the threshold friction velocity (u_{*t}). The u_{*t} utilized represented either a before or after rain value, depending upon whether or not precipitation exceeded 5.08 cm during a month. If precipitation exceeded this amount, the "after-rain" u_{*t} value was used for all succeeding months until the time of a significant tillage operation or plant emergence. Values of the threshold friction velocity for different soil types both before and after rain have been reported by

B-15

Gillette and Passi. The value of u_t was then calculated using the value of u_{*t} determined and C_d. Once u_t is determined, then x is calculated and the incomplete gamma function is evaluated. Following determination of the incomplete gamma function, the flux for each month was calculated.

Wind erosion was assumed to be zero from the time of plant emergence until harvest (i.e., the percent of time when the ground is planted). Separate flux estimates were made for fall-planted crops and spring-planted crops. This meant that flux estimates were only calculated from July to October (for fall-planted crops) and from September until May (for spring-planted crops). This approach is consistent with the methodology utilized by Gillette and Passi. However, because they were evaluating the erosion potential over a multi-year time frame, Gillette and Passi utilized previous year precipitation information to assign the threshold friction velocity to an area. In this work, the before rain u_{*t} value was always utilized for January for spring planted crops rather than evaluating whether or not any month between September and December of the previous year had more than 5.08 cm of precipitation.

Once the emission flux potential for each month for each crop type (fall- or spring-planted) for each State was calculated, then information on the number of acres of spring- or fall-planted crops in each State were required (and the number of seconds per month) to determine the emissions. The number of acres of crops planted in each State was obtained for each of the six years from the USDA. Evaluation of which crops were spring-planted or fall-planted for each State was made using information available from the USDA.

State-level PM_{10} estimates were distributed to the county-level using estimates of county rural land area from the U.S. Census Bureau. The following formula was used:

$$County\ Emissions\ =\ \frac{Actual\ tillage\ acres/county}{Total\ State\ tillage\ acreage}\ x\ State\ Emissions \tag{21}$$

$PM_{2.5}$ emissions were then calculated from the county-level PM_{10} emissions by applying the AP-42 particle size multiplier for industrial wind erosion of 0.2 (or 0.40 of PM_{10}), as no other particle size data were available.

3.h. <u>Cattle Feed Lots</u>: County-level PM_{10} emission estimates for cattle feed lots were estimated using activity data from the Census of Agriculture (head of cattle per county) and a PM_{10} emission factor of 17 tons per 1,000 head. The following formula was used:

$$County\ Emissions\ =\ \frac{County\ Head\ of\ Cattle}{1,000}\ x\ 17 \tag{22}$$

PM$_{2.5}$ emissions were then calculated from the county-level PM$_{10}$ emissions by applying the AP-42 particle size multiplier for agricultural tilling of 0.10 or (0.476 of PM$_{10}$).

The National Particulates Inventory also includes NH$_3$ emissions for cattle feet lots, which were estimated based on the 1985 NAPAP Inventory estimates.

4. OTHER AREA AND MOBILE SOURCES

The basis for the emission estimates for most (non- fugitive dust) area source categories was the 1985 NAPAP Area Source Emissions Inventory, with the exception of non-road mobile sources, and prescribed burning. This section discusses area source emission estimates performed for this study other than those for fugitive dust. The methodology used to estimate emissions for 1990, including the sources for growth indicators and updated emission factors, are discussed. Non-road gasoline, mobile source emission estimates are based on a 1990 non-road emission inventory compiled by EPA. Non-road diesel emission estimates are derived by using the Non-road model as described in "Methodologies that are New" earlier in this document.

As with the point sources, the 1985 NAPAP Inventory contained total suspended particulate (TSP) emissions. Except where noted, these TSP emissions were grown to 1990 and then particle size multipliers were applied to estimate PM$_{10}$ and PM$_{2.5}$ emissions. Ammonia emissions were estimated by growing NH$_3$ emissions taken from the 1985 NAPAP Inventory.

4.a. Growth Indicators: Emission estimates from the 1985 NAPAP Inventory were grown to 1990 based on historical BEA earnings data (refer to page 4-37 of the Procedures Document), historical estimates of fuel consumption, or other category-specific growth indicators.

The State Energy Data System (SEDS) data were used as an indicator of emissions growth for the area source fuel combustion categories and for the gasoline marketing categories. (Refer to Table 4.3-9, page 4-70 of the Procedures Document). SEDS reports fuel consumption by sector and fuel type. Since fuel consumption is the activity level used to estimate emissions for these categories, fuel consumption is a more accurate predictor of changes in emissions, compared to other surrogate indicators such as earnings or population. A log linear regression procedure was used to fill in missing data points for fuel consumption categories if at least three data points in the time series (1985 to 1989) were available.

Additional data were gathered for several categories for use in the emission projections. Growth indicators, other than BEA or SEDS data, were developed for petroleum refinery fugitives and several non-road vehicle source categories, including aircraft (commercial and civil), railroads, and marine vessels (other than gasoline-powered).

4.b. Residential Wood Combustion: Residential Wood Emissions from residential wood combustion were estimated for 1985 through 1997 using annual wood consumption and an emission factor. The following general equation) was used to calculate emissions:

$$E_{year} = Activity \times EF \times \left(1 - \frac{CE}{100} \right) \tag{23}$$

where: E_{year} =   county emissions (tons)
       Activity   =   wood consumption (cords)
       EF   =   emission factor (tons/cord)
       CE   =   control efficiency (percent)

Activity was based on EPA's County Wood Consumption Estimation Model. This model was adjusted with heating degree day information, and normalized with annual wood consumption estimates. AP-42 emission factors for CO, NO_x, PM_{10}, $PM_{2.5}$, SO_2 and VOC were used. A control efficiency was applied nationally to PM_{10} and $PM_{2.5}$ emissions for the years 1991 through 1996.
       EPA's County Wood Consumption Estimation Model is based on 1990 data and provides county level estimates of wood consumption, in cords. Model F of the overall Model was used to estimate the amount of residential wood consumed per county, using a sample set of 91 counties in the northeast and northwestern United States. Model F calculates estimates of cords of wood consumed per household as a function of the number of homes heating primarily with wood with a forced intercept of zero. Using the Model F results, the percentage of the population heating with wood, the number of households in a county, land area per county, and heating degree days, county-level wood consumption for 1990 was estimated.

       Heating Degree Days: A heating degree day is the number of degrees per day the daily average temperature is below 65 degrees Fahrenheit. These data were collected for one site in all states (except Texas and California where data were collected for two sites) for each month and summed for the year. An average of the two sites was used for Texas and California. This information is used to adjust the model, which is partially based on 1990 heating degree days, to the appropriate year's heating degree data.

$$Adjusted\ Model_{year} = \frac{State\ hdd\ Total_{year}}{State\ hdd\ Total_{1990}} \times County\ Model_{1990} \tag{24}$$

where: Adjusted Model   =   county wood consumption (cords)
       State hdd Total   =   total heating degree days (degrees Fahrenheit)
       County Model   =   EPA model consumption (cords)

National Wood Consumption: The Adjusted Model wood consumption estimate was normalized on a national level using the U.S. Department of Energy (DOE) estimate of residential U.S. wood consumption. This value in 1997 was reported as 414 trillion British thermal units (Btu).   Dividing by 20 million Btu/cord yields an account of cords over the nation consumed per year. Consumption for the years 1985, 1986, and 1988 were unavailable from the DOE. Known year's consumption and heating degree days were used to estimate these years. The 1985 DOE estimate was calculated using the ratio of 1985 total heating degree days to 1984 total heating degree days multiplied by the 1984 DOE wood consumption estimate. The 1986 DOE estimate was calculated using the ratio of 1986 total heating degree days to 1985 total heating degree days multiplied by the "calculated" 1985 DOE wood consumption estimate. The 1988 DOE estimate was calculated using the ratio of 1988 total heating degree days to 1987 total heating degree days multiplied by the 1987 DOE wood consumption estimate. The following equation shows normalization of the Adjusted Model:

$$Activity \ = \ Adjusted \ Model_{year} \ \times \ \frac{DOE_{year}}{\sum Adjusted \ Model_{year}} \tag{25}$$

where: Activity   =   normalized county consumption (cords)
       Adjusted Model   =   county wood consumption (cords)
       DOE   =   DOE national estimate of residential wood consumption
                                   (cords)

Emission Factors: Emission factors were obtained from Table 1.10-1 of AP-42, Emission Factors for Residential Wood Combustion, for conventional wood stoves.

Control Efficiency: A control efficiency was applied nationally to PM_{10} and $PM_{2.5}$ residential wood combustion for the years 1991 through 1996. The control efficiency for all pollutants for the years 1985 through 1990, and for VOC, NO_x, CO, and SO_2 for 1991 through 1996 is zero.

4.c. Residential Nonwood Combustion: The 1990 SO_2 and PM NET emissions are the same as the 1990 Interim Inventory emissions. The 1991 through 1994 emissions were estimated by applying growth factors to the 1990 Interim Inventory emissions. The growth factors were obtained from the prereleased E-GAS, version 2.0. The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions as shown:

B-19

$$Emissions_{(county,SCC,year)} = Growth_{(county,SCC,year)} \times Emissions_{(county,SCC,1990)} \qquad (26)$$

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate.

4.d. <u>Highway Vehicles</u>: In 1994, EPA released a computer model, with the acronym PART5, that can be used to estimate particulate emission rates from in-use gasoline and diesel-fueled motor vehicles (refer to Reference 20, page 4-200 of the Procedures Document). It calculates particle emission factors in grams per mile from on-road automobiles, trucks, and motorcycles, for particle sizes up to 10 microns. PART5 was used to calculate on-road vehicle PM_{10} and $PM_{2.5}$ ($PM_{2.5}$ for the years 1990-1996 only) emission factors from vehicle exhaust, brake wear, tire wear, and reentrained road dust from paved and unpaved roads (see sections 4.8.2.3 and 4.8.2.4 for details on road dust emissions), and SO_2 vehicle exhaust emission factors.

Basic assumptions regarding inputs to PART5 were made that apply to all PART5 model runs, and include the following:

!   The transient speed cycle was used.

!   Any county with an existing I/M program was given I/M credit from PART5, regardless of the details of the I/M program. PART5 gives credit based on the assumption that high emitting vehicles will be forced to make emission reducing repairs and that an existing I/M program will deter tampering. This only affects lead and sulfate emissions from gasoline-powered vehicles.

!   Using the input parameter BUSFLG, bus emission factors for all rural road types, urban interstates, and other freeways and expressways road types were modeled using the PART5 transit bus emission factors, while bus emission factors for all other urban road types were modeled using the PART5 Central Business District bus emission factors.

Registration Distribution. The vehicle registration distribution used was also common to all PART5 model runs. PART5 uses the same vehicle classifications as the MOBILE model, except that the MOBILE HDDV class is broken into five subclasses in PART5.

To maintain consistency with the NET Inventory, the year specific vehicle registration distribution used in the MOBILE modeling for the NET Inventory was adapted for this analysis. This registration distribution was modified by distributing the MOBILE HDDV vehicle class distribution among the five PART5 HDDV subclasses (2BHDDV, LHDDV, MHDDV, HHDDV,

and BUSES). This was accomplished using HDDV subclass-specific sales, survival rates, and diesel market shares.

Speed. The speed inputs documented in the procedures document were used in the PART5 modeling as well, with the exception that the maximum allowable speed in PART5 is 55 mph, so the rural interstate speed was changed from 60 mph to 55 mph for the PART5 modeling (see table 4.6-22 in the Procedures Document). Emission factors were calculated for each combination of state, I/M status, month, vehicle type, and speed. VMT data for each county/month/vehicle type/road type were mapped to the appropriate emission factor.

HDDV Vehicle Class Weighting. After PART5 emission factors are generated, the PART5 HDDV subclass emission factors (2BHDDV, LHDDV, MHDDV, HHDDV, and BUSES) are weighted together to develop a single HDDV emission factor, to correspond with the VMT data already developed for the NET Inventory. These weighting factors are based on truck VMT by weight and truck class from the Truck Inventory and Use Survey and FHWA's *Highway Statistics*.

Exhaust PM Emissions. Monthly, county-level, SCC-specific PM emissions from on-road vehicle exhaust components were calculated by multiplying year specific monthly county-level, SCC-specific VMT by year specific state-level, SCC-specific exhaust PM emission factors generated using PART5. Since none of the inputs affecting the calculation of the PM exhaust emission factors vary by month, only annual PM exhaust emission factors were calculated. PART5 total exhaust emission factors are the sum of lead, soluble organic fraction, remaining carbon portion, and direct SO_4 (sulfates) emission factors.

Exhaust SO_2 Emissions. National annual SO_2 on-road vehicle exhaust emission factors by vehicle type and speed were calculated using PART5. These emission factors calculated within PART5 vary according to fuel density, the weight percent of sulfur in the fuel, and the fuel economy of the vehicle (which varies by speed). None of these parameters vary by month or state. Monthly/county/SCC-specific SO_2 emissions were then calculated by multiplying each county's monthly VMT at the road type and vehicle type level by the SO_2 emission factor (calculated for each vehicle type and speed) that corresponds to the vehicle type and road type.

PM Brake Wear Emissions. The PART5 PM emission factors for brake wear are 0.0125 grams per mile for PM_{10} and 0.005 grams per mile for $PM_{2.5}$. This value was applied to estimate brake wear emissions for all vehicle types.

PM Tire Wear Emissions. PART5 emission factors for tire wear are proportional to the average number of wheels per vehicle. The emission factor is 0.002 grams per mile per wheel for PM_{10} and 0.0005 grams per mile per wheel for $PM_{2.5}$. Therefore, separate tire wear emission factors were calculated for each vehicle type. Estimates of the average number of wheels per vehicle by vehicle class were developed using information from the *Truck Inventory and Use Survey*. Tire wear PM emissions were then calculated at the monthly/county/SCC level by

B-21

multiplying the monthly/county/SCC level VMT by the tire wear emission factor for the appropriate vehicle type.

   Pre-1996 Calculation of Ammonia (NH_3) Emission Factors. Little research has been done to date on ammonia (NH_3) emission factors from motor vehicles. The most comprehensive vehicle testing including NH_3 emission factors available for use in this analysis is summarized in a report by Volkswagen AG (refer to Reference 19, page 4-200, of the Procedures Document). In the testing program described in this report, 18 different Volkswagen/Audi vehicles from the 1978 through 1986 model years were tested. The vehicles were selected to represent a cross-section of the Volkswagen/Audi passenger car production program. The vehicles all had either 4 or 5 cylinder gasoline or diesel engines. Seven of the gasoline vehicles were equipped with 3-way catalysts with oxygen sensors, seven of the vehicles were diesel-fueled, and the remaining four vehicles were gasoline vehicles with no catalysts.

   Emissions from each of these vehicles were measured using a chassis dynamometer over three different test procedures: the U.S. FTP, the U.S. Sulfate Emission Test (SET), and the U.S. Highway Driving Test. The FTP includes both cold and hot engine starts with a cumulative mileage of 11.1 miles over 505 seconds. The SET simulates 13.5 miles of travel on a freeway in Los Angeles with heavy traffic over a time of 1,398 seconds. The Highway Driving Test, also known as the Highway Fuel Economy Test (HFET), results in an average speed of 48.1 mph over 10.2 miles with a maximum speed of 59.9 mph. Both the SET and the HFET are hot start tests (no cold starts are included). Each vehicle was tested on all three test cycles on the same day, with three to five repeated measurements carried out for each vehicle on consecutive days.

   The mean results of Volkswagen's emission testing program were reported for each of the 18 vehicles tested and for each of the test cycles. The report also shows the total mean value over all three tests by engine type (gasoline with catalyst, gasoline without catalyst, and diesel). These values accounting for all three test cycles were used in this analysis to calculate NH_3 emission since most types of driving would be included in one of the three test cycles (i.e., urban driving would be represented by the FTP; stop and go driving on expressways would be represented by the SET; and freeway driving would be represented by the HFET). These mean emission factors are shown below.

Engine Type	Mean NH_3 Emission Factor (grams/mile)
Gasoline Engine without Catalyst	0.00352
Gasoline Engine with 3-Way Catalyst	0.13743
Diesel Engine	0.00188

   Using the NH_3 emission factors listed above, emission factors by vehicle type and model year were calculated using MOBILE5b data listing the fraction of vehicles with 3-way catalysts by vehicle type and travel fractions from MOBILE5b output by model year and vehicle type. For the Trends analysis, motorcycles were assigned the non-catalyst gasoline engine emission factor while all diesel vehicle types were assigned the diesel engine emission factor listed above.

   To calculate the LDGV emission factor for 1995, a MOBILE5b run was made to produce by-model-year output for LDGVs in 1995. The by-model-year travel fractions were extracted from the

resulting MOBILE5b output file. Then, for each of the 25 model years included in the by-model-year output, a weighted emission factor was calculated by multiplying the fraction of LDGVs with 3-way catalysts in that model year by the emission factor listed above for gasoline engines with 3-way catalysts (i.e., 0.13743 g/mi) and adding to this the product of the fraction of LDGVs without 3-way catalysts in that model year and the emission factor for gasoline engines without 3-way catalysts (i.e., 0.00352 g/mi). This weighted emission factor was then multiplied by the LDGV travel fraction for that model year, giving a model year-weighted emission factor. This procedure was repeated for each of the 25 model years included in the by-model-year output for 1995 and the 25 model-year weighted emission factors were then summed to give the composite 1995 LDGV NH_3 emission factor.

The above procedure was repeated for 1995, 1996, and each projection year for LDGVs, LDGT1s, LDGT2s, and HDGVs.   Note that the NH_3 emission factors for each gasoline vehicle type increase with time as the fraction of vehicles with 3-way catalysts increases, since the Volkswagen study showed that NH_3 emission factors for gasoline vehicles with catalysts are significantly higher than those for vehicles without catalysts.

Calculation of Emissions: Once the emission factors for all pollutants and VMT were calculated at the level of detail described above for 1995, 1996, and each of the projection years, emissions were calculated by multiplying the appropriate emission factors by the corresponding VMT values. Emissions for the MOBILE5b pollutants (VOC, NO_x, and CO) were calculated with emission factors and VMT at the month, county, roadway type, and vehicle type (for the eight MOBILE5b vehicle types) level of detail. The emission factors for the PART5 pollutants (PM_{10}, $PM_{2.5}$, and SO_2) did not vary by month, so the same emission factors were multiplied by the monthly VMT at the county, roadway type, and vehicle type (for the 12 PART5 vehicle types) level of detail. Ammonia emission factors varied only by vehicle type, so the eight emission factors by vehicle type were multiplied by VMT representing the same vehicle type at the monthly, county, and roadway type level of detail. Emissions for all pollutants were calculated by multiplying the appropriate emission factor in grams per mile by the corresponding VMT in millions of miles, and then converting the answer to units of tons of emissions.

Emission factors were not calculated separately for each county. To determine the emission factor sets to be modeled in each State, a county-level database was prepared for each year modeled. For each county, the control programs applicable in that year were indicated. The data base also included information on non-default inputs to be modeled, such as registration distributions and other State-supplied data from OTAG, for each county. Next, for each State, all unique combinations of control programs and other non-default inputs were determined for each modeled year. MOBILE5b model runs were then made modeling each of these unique combinations. Each combination was identified using the county code of one of the counties with this combination of controls and inputs. To apply the emission factors to the appropriate counties, a county correspondence file was developed which mapped all counties with the same unique set of input data and control programs to the MOBILE5b emission factors modeled for the county representing that unique combination of inputs and control programs. In some States, a single set of emission factors was applied to all counties in the State, while in other States, a separate set of emission factors was calculated for each county. Most States, however, fell in between these two extremes with several sets of emission factors calculated for the State, with each set applying to one or more counties within the State.   A similar process was followed in mapping the PART5 emission factors to the appropriate counties.

1996 and 1997 Ammonia emission factors: NH_3 emission factors used in estimating 1996 and 1997 values are new. The pre-1996 values are based on a European Volkswagen study **(**Volkswagen AG Research and Development, "Unregulated Motor Vehicle Exhaust Gas Components," Wolfsburg, Germany, March 1989). Emission factors for 1996 and beyond were estimated using the Office of Mobile Sources (OMS) NH_3 emission factors, to capture the impact of catalytic converters on American vehicles.

4.e. Non-Road Gasoline Vehicles*:*   Non-road sources include motorized vehicles and equipment that are not normally operated on public roadways. The non-road mobile source emission estimates in the NET Inventory are based on 1990 non-road emission estimates compiled by EPA. The non-road data contains a total emission estimate for non-road sources at the county level. These emission estimates include all non-road sources except aircraft, commercial marine vessels, railroads, and fugitive road dust. Three of these categories are discussed below. The non-road sources not included in the estimates were determined by growing the applicable NAPAP source categories. The non-road emission estimates were developed from non-road emission inventories for 27 ozone nonattainment areas (NAAs) by EPA's OMS. The OMS inventories contained 1990 emission estimates at the SCC-level for each county within the 27 NAAs. (Refer to Reference 1, page 4-255, of the Procedures Document).

EPA performed a two step process to convert the OMS emission estimates to county/ SCC-level emission estimates from the NAA level. The first step was to use the OMS 1990 non-road emission estimates for the 27 ozone NAAs to estimate non-road emissions for the rest of the country. In the second step, total non-road emission estimates for each county were used to create 1990 county/SCC-level non-road emission estimates. Aircraft, railroads, and marine vessel estimates were derived differently, as discussed below.

Aircraft. Activity levels for aircraft are measured by the number of landing-takeoff operations (LTOs). Annual LTO totals are compiled by the Federal Aviation Administration (FAA) on a regional basis. Commercial aircraft growth was derived from the summation of air carrier and air taxi regional totals of LTOs from FAA-operated control towers and FAA traffic control centers. These data were compiled on a regional basis, so the regional trends were applied to each State. Civil aircraft growth indicators were also developed from regional LTO totals. Civil aircraft activity levels were determined from terminal area activity for the years 1985 through 1989, and from a 1990 forecast of terminal area activity. Military aircraft LTO totals were not available; consequently, BEA data on military sector economic growth were used.

Railroads. Railroad data are provided by the Association of American Railroads (AAR). National totals of revenue-ton-miles for the years 1985 through 1990 were used to estimate changes in activity during this period. The national growth was applied to each State and county.

Marine Vessels. Marine vessel activity is recorded annually by the U.S. Army Corp of Engineers (COE). Cargo tonnage national totals are used to determine growth in diesel- and residual-fueled vessel use through the year 1989. Gasoline-powered vessels are used predominantly for recreation, so growth for this category is therefore based on population.

Diesel: Refer to "Methodologies that are New" on the first page of this update.

We continue to upgrade the emission estimates for $PM_{2.5}$ and NH_3, and expect more significant changes to the 1990 through 1997 estimates in the **1999** Trends Report.